Environmental Effects

- Understanding fire history - Objectives
- Effects on soil
- Effects on water
- Introduction to effects on air quality

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Our Forest Has Changed!

Fire History

- Fire History >20,000 BP
- The “Native” American Period
- The European “Invasionary” Period.
- Fire Exclusion Period
- The Fire Reintroduction Period

> 20,000 yrs BP

Eastern US – Virginia Impacted by:
- Natural Fire Starts -

Evidence:

Peat Bogs

Soil Charcoal Layers

20,000 YBP – 1600 AD

New Source of Fire: “Native” Americans

Evidence: Soil, Bogs, Historical Records, Tree Rings

George Percy (1607)

Two days after first sighting the coast of Virginia in 1607, the Jamestown colonists noticed "…great smokes of fire…" rising from deep in the woods. "We marched to these smokes," recalled George Percy, "and found that the savages had been burning down the grass as, we thought, either to make their plantation there or else to give signs to bring their forces together, and so to give us battle."

Wood (1634)

"There is no underwood saving in swamps and low grounds that are wet…for it being the custome of the Indians to burne the wood in November…it consumes all the underwood and rubbish…there is scarce a bush or bramble or any cumbersome underwood to bee seene"

Native American Reasons to "Set Fire":

(Mimicked by early settlers so they would not starve!)

- **Hunting**
- **Crop Management**
- **Insect Harvesting**
- **Pest Management**
- **Improve Growth and Yield**
- **Fireproof Surrounds**
- **Warfare and Signaling**
- **Economic Extortion**
- **Travel Clearance**
- **Felling Trees**
- **Riparian Area Management**

Impact of Native American Burning?

Generally accepted estimates of population levels before 1500 are conservatively placed at between 9.8 million and 12.25 million for North America (Fagan 2000, Ramenovsky 1987, Williams 1992).

Estimates of the cleared land needed to support a person range from 2 or 3 acres to 30 or 40 acres for all cleared and burned land (Williams 1992).

WAG/EC -

If we assume that half the population was part of the eastern woodland culture and each person represented 10 burned acres. Thus 55 million acres would need to be cleared by rotational burning …

This is an area equal to the size of Virginia and North Carolina combined which must be burned every 2-4 years.

Steve Pyne (1982):

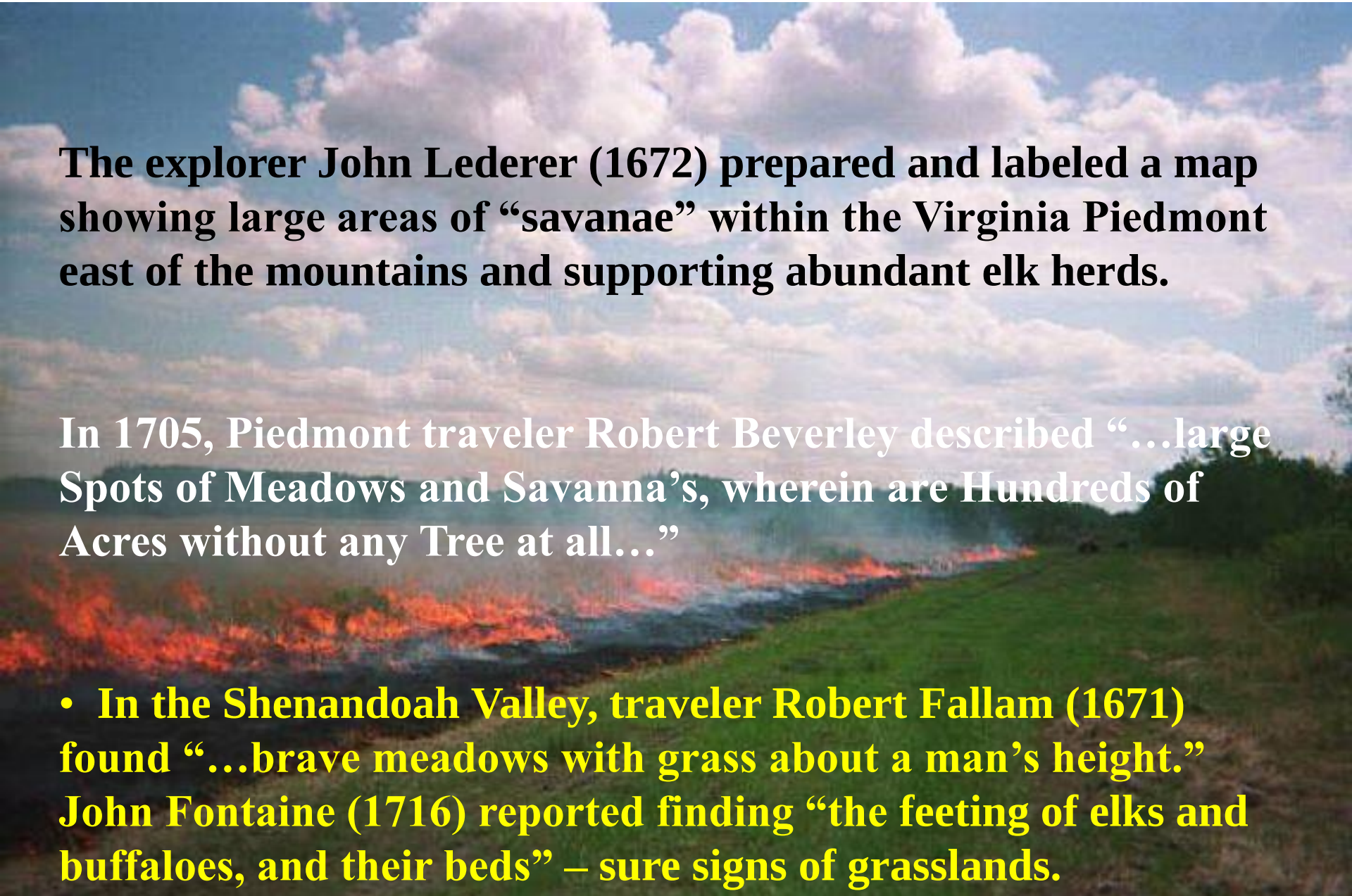
“The modification of the American continent by fire at the hands of Asian immigrants was the result of repeated, controlled, surface burns on a cycle of one to three years, broken by occasional holocausts from escape fires and periodic conflagrations during times of drought.”

Steve Pyne (1982):

“Even under ideal circumstances, accidents occurred: signal fires escaped and campfires spread, with the result that valuable range was untimely scorched, buffalo driven away, and villages threatened. So extensive were the cumulative effects of these modifications that it may be said that the general consequence of the Indian occupation of the New World was to replace forested land with grassland or savannah, or, where the forest persisted, to open it up and free it from underbrush. Conversely, almost wherever the European went, forests followed.

Steve Pyne (1982):

Extensive Grasslands Created



The explorer John Lederer (1672) prepared and labeled a map showing large areas of "savanae" within the Virginia Piedmont east of the mountains and supporting abundant elk herds.

In 1705, Piedmont traveler Robert Beverley described "…large Spots of Meadows and Savanna's, wherein are Hundreds of Acres without any Tree at all…"

- **In the Shenandoah Valley, traveler Robert Fallam (1671) found "…brave meadows with grass about a man's height." John Fontaine (1716) reported finding "the feeting of elks and buffaloes, and their beds" – sure signs of grasslands.**

Native Burning Differed from "Nature":

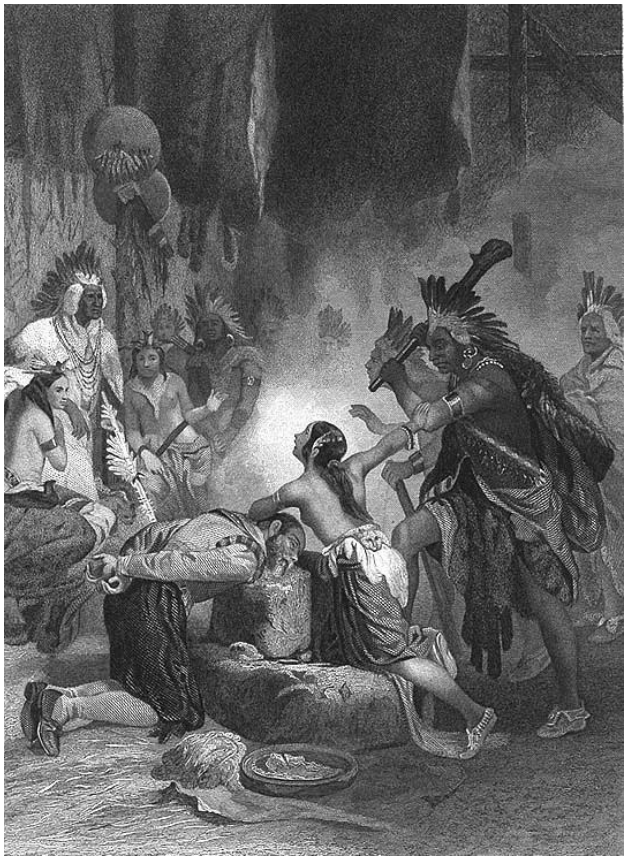
Seasonality of Burning: Seasons extended beyond times of potential lightening starts

Frequency of Burning: Much higher frequency of fire starts

Intensity of Burning: Decreased variation, mostly low intensity

1600 – 1900 European Invasion Period

Evidence: Soil, Bogs, Historical Records, Tree Rings

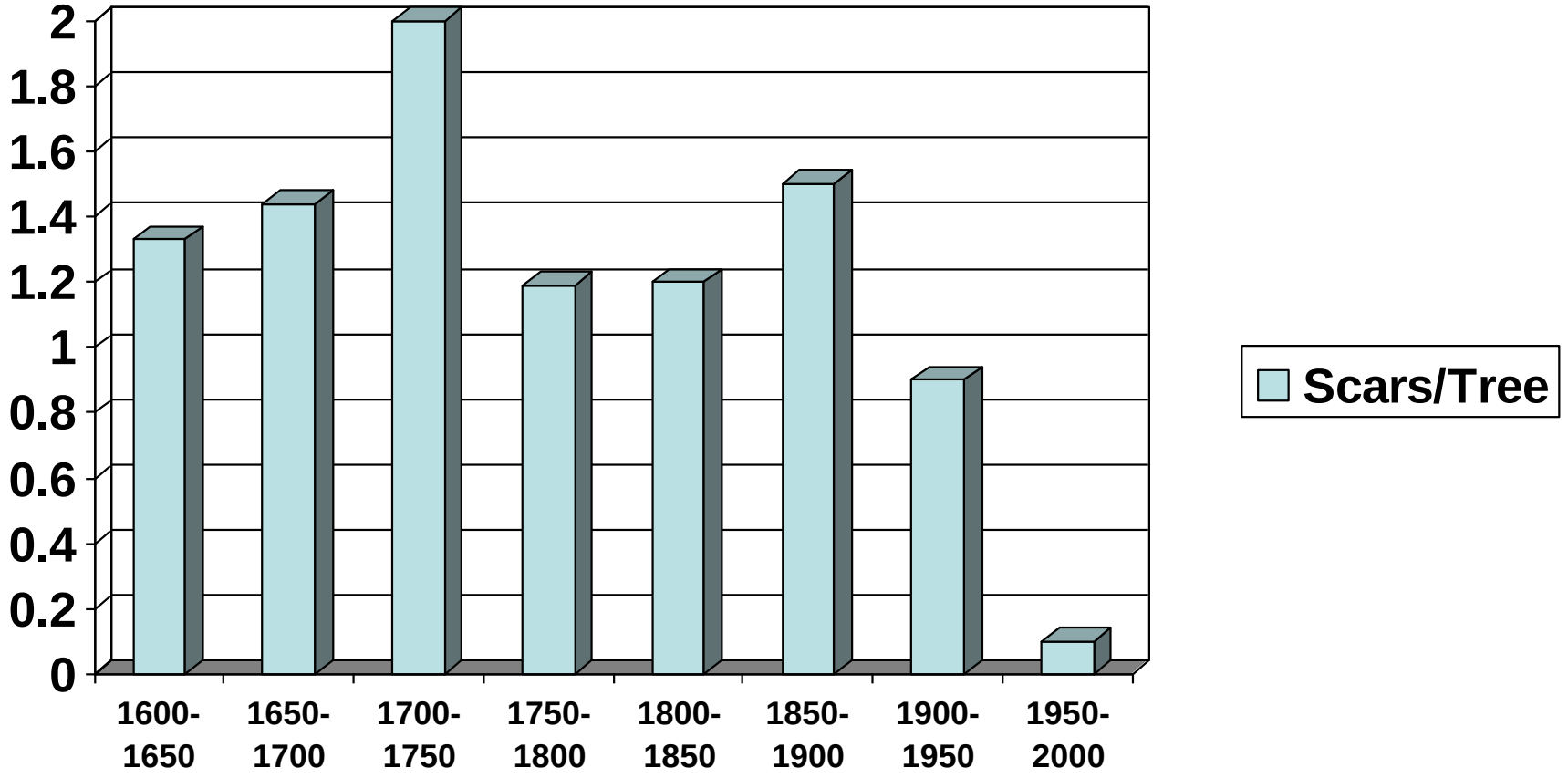


Hammond (1880)

"The early settlers in this region were stock raisers and kept up the Indian practice of burning off the woods during the winter."

Number of Fire Scars/Tree

(Shumway et al. 2001)



Hough (1882)

- Land Survey of Pennsylvania and Virginia in 1800's
- 2-14% of all land burned annually
- Average fire return frequency = 11 years
- Area of Penn. + Va. = 54 million acres
- Annual burn area in just these two states = 4.8 million acres
- Average area burned in **whole US** today ~5.5 million acres

Miramichi Fire

(October 1825)

Location: Maine and New Brunswick

Area: ~ 3 million acres

Lives Lost: 160

Source of Ignition: Uncontrolled settler and logging fires

Peshtigo Fire

(October 8, 1871)

Location: **Wisconsin and Michigan**

Area: **3.78 million acres**

Lives Lost: **1,500**

Source of Ignition: **Uncontrolled settler and logging fires**

Thumb Fire

(September 1-5, 1881)

Location: Michigan

Area: 1.0 million acres

Lives Lost: 282

Source of Ignition: Uncontrolled settler and logging fires, and August 31 lightning strikes

The "BIG BLOWUP"

August 20-21, 1910

Location: Idaho and Montana

Area: ~ 3 Million Acres

Lives Lost: 85

Source of Ignition: Various uncontrolled settler, railroad and logging fires

1900-1970: Fire Exclusion Period

- Creation of the US Forest Service
- Creation of State Fire Organizations
- Establishment of Rural Volunteer Fire Stations

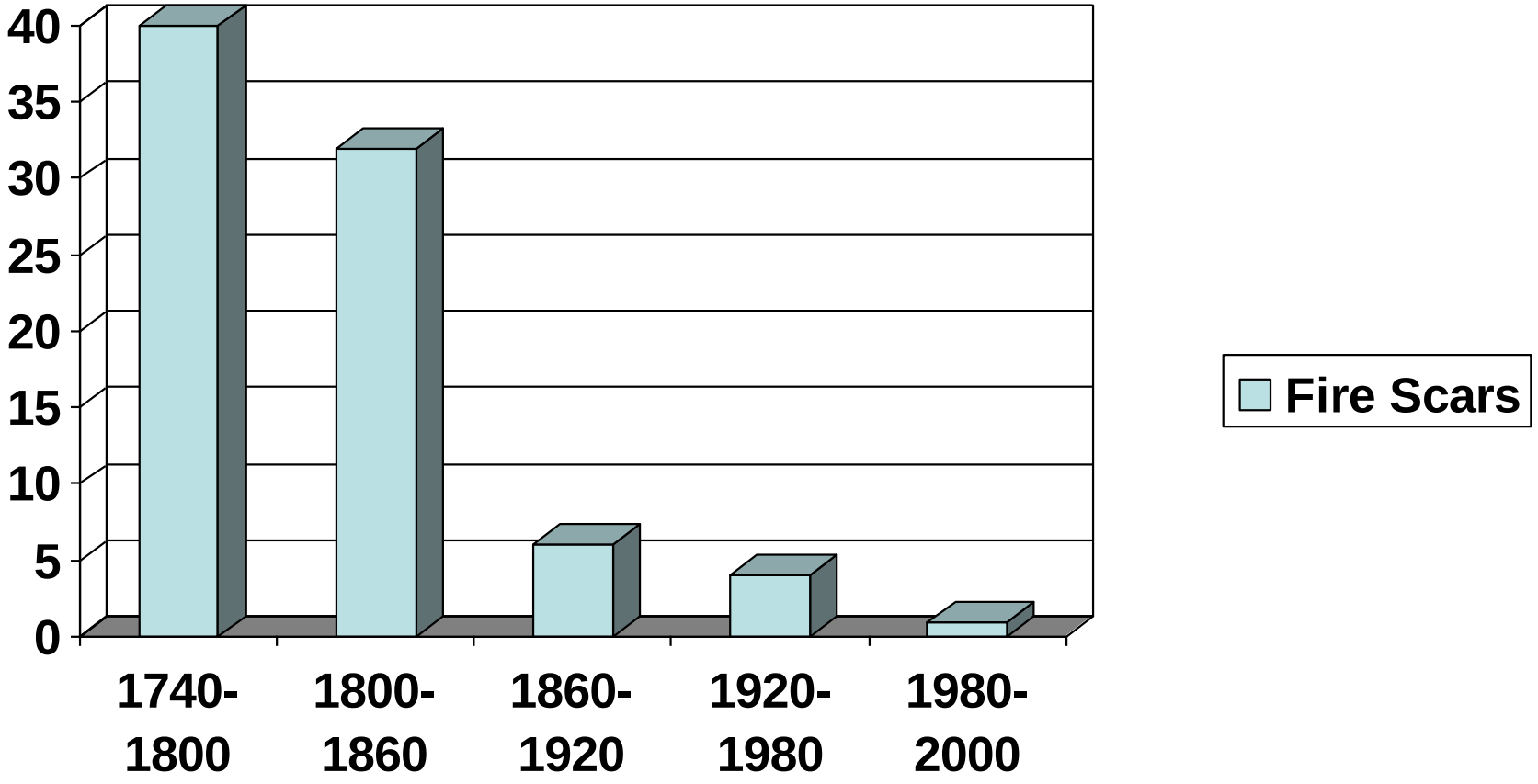
THE 10 AM POLICY:

'When immediate control is not thus attained, the policy then calls for prompt calculating of the problems of the existing situation and probabilities of spread, and organizing to control every such fire with the first work period.
Failing in this effort, each succeeding day will be planned and executed with an aim, without reservation, of obtaining control before ten o'clock of the next morning.'

10 a.m. policy, National Forest Manual, 1935-1978

Number of Fire Scars

(Clutter and Guyette 1994)



But The Policy Did/Does Not Work:

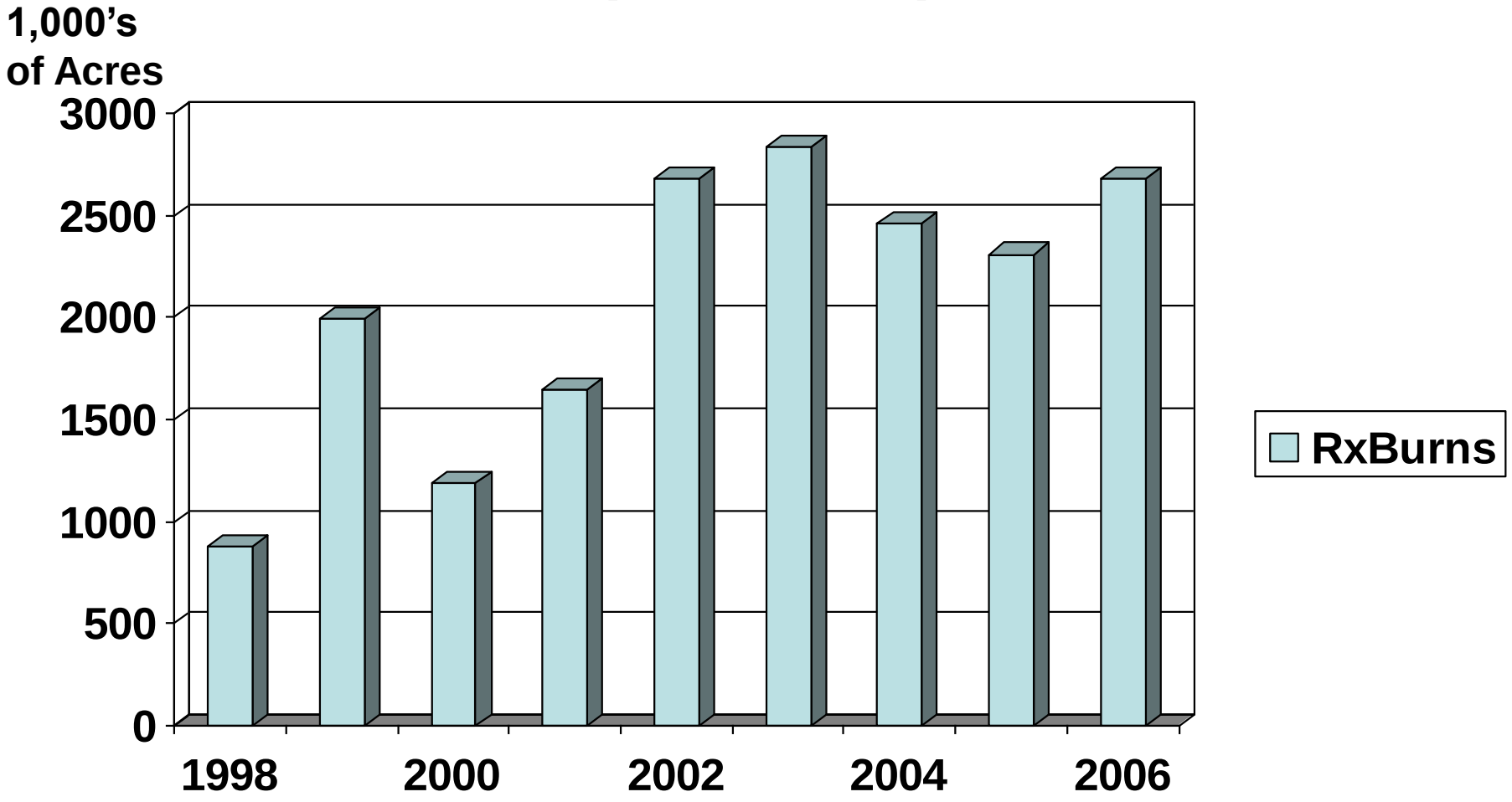
- **Tillamook Burn – 1933 – 350,000 ac**
- **Maine Fires - 1947 – 205,000 ac**
- **Laguna Fire – 1970 – 175,000 ac**
- **Yellowstone – 1988 – 800,000 ac**
- **Dunn/Glen - 1999 – 288,000 ac**
- **Biscuit Fire – 2002 – 500,000 ac**
- **Cedar/Old Complex – 2003 – 370,000 ac**
- **Harris/Witch Complex – 2007 – 287,000 ac**

1970-Present: Fire Reintroduction

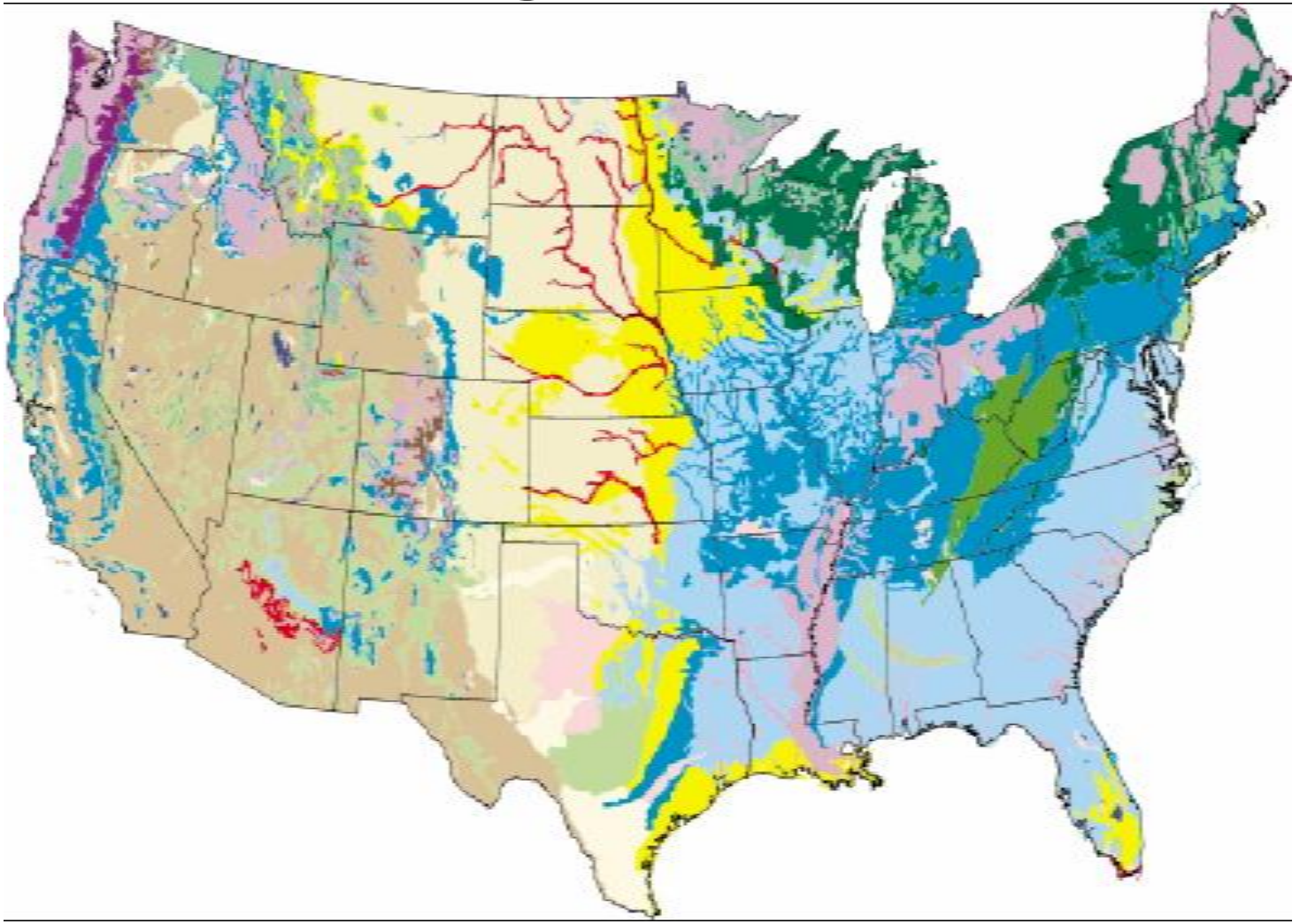
- 1963 – USDI Park Service Rept. Acknowledges Fire's Role In Maintaining Some Ecosystems
- 1968 – First Park Service WFU and Rx Burns

Prescribed Fires

(1998-2006)



Fire Regimes for US



The Nature Conservancy
USGS science for a changing world
FireLab
SYSTEMS FOR ENVIRONMENTAL MANAGEMENT

Fire Regimes:

- **I – 0-35 year frequency and low severity (most surface fires) to mixed severity (less than 75 % of the dominant overstory vegetation is replaced)**
- **II – 0-35 year frequency and high severity (stand replacement: greater than 75 percent of the dominant overstory vegetation is replaced)**
- **III – 35-200+ year frequency and mixed severity**
- **IV – 35-200+ year frequency and high severity**
- **V – 200+ year frequency and high severity**

Condition Classes:

- **Condition Class 1** — ***Within the natural (historical) range*** **of variability of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances**
- **Condition Class 2** — ***Moderate departure*** **from the natural (historical) regime of vegetation, fuels, fire frequency, severity and pattern; and other disturbances**
- **Condition Class 3** — ***High departure*** **from the natural (historical) regime of vegetation, fuel, fire frequency, severity and pattern; and other disturbances**

Reference Conditions (Bps):
(Virginia Forest Types)

Name	Early Seral	MidSer.Closed	MidSer.Open	LateSer.O.	LateSer. C.	Fire Freq (MFI)	Dominant Fire Regime
	(%)					Yrs	
Appalachian Shortleaf Pine	10	15	25	40	10	6	I
Appalachian Virginia Pine	30	60	0	0	10	23	I
Maritime Live Oak Forest (VA, TX)	9	6	22	56	71	5	I
Mixed Mesophytic Hardwood Forest	5	25	5	10	55	50	III
Table Mountain Pine/Pitch Pine	15	15	25	25	20	5	I
Eastern Dry-Xeric Oak-Hickory	15	20	30	25	10	8	I
Western Dry-Xeric Oak-Hickory	10	10	20	50	10	8	I
Oak-Hickory Western Mesophytic	10	25	10	15	40	36	III
Oak-Hickory Northeast	2	6	34	54	5	13	I
Oak-Hickory-Pine	5	15	30	20	30	10	I
Oak Flats	4	16	80	n.a.	n.a.	17	I
Appalachian Dry-Mesic Oak Forest	8	13	20	47	12	14	I
Piedmont Oak-Hickory-Shortleaf Pine	7	8	20	41	24	7	I
Piedmont Floodplain Forest	15	27	6	4	48	59	III
Atlantic White Cedar Forest	11	42	13	34	n.a.	47	IV
Southern Floodplain Forest	8	35	n.a.	n.a.	57	32	I
Eastern Spruce-Fir #1	15	30	0	0	55	500	V

Effects of Burning On Plant and Animal Communities

- **Dependant on:**
  1. **Intensity**
  2. **Location**
  3. **Timing/Frequency**

- **High Intensity/Frequency: Simplifying**
- **Low Intensity/Frequency: Diversifying**
- **Fire Exclusion: Simplifying**

Fire Effects on the Environment

- Impacts on Soil
- Impacts on Water
- Impact on Air Quality

Impacts on Soil

Physical Properties –

– Hydrophobic Zones Formed

– Erosion Accelerated

Chemical Properties –

- **Nutrient Gains (metals, cations)**
- **Nutrient Losses (nitrogen, carbon)**
- **pH Increase**

Impacts on Soil

Erosion

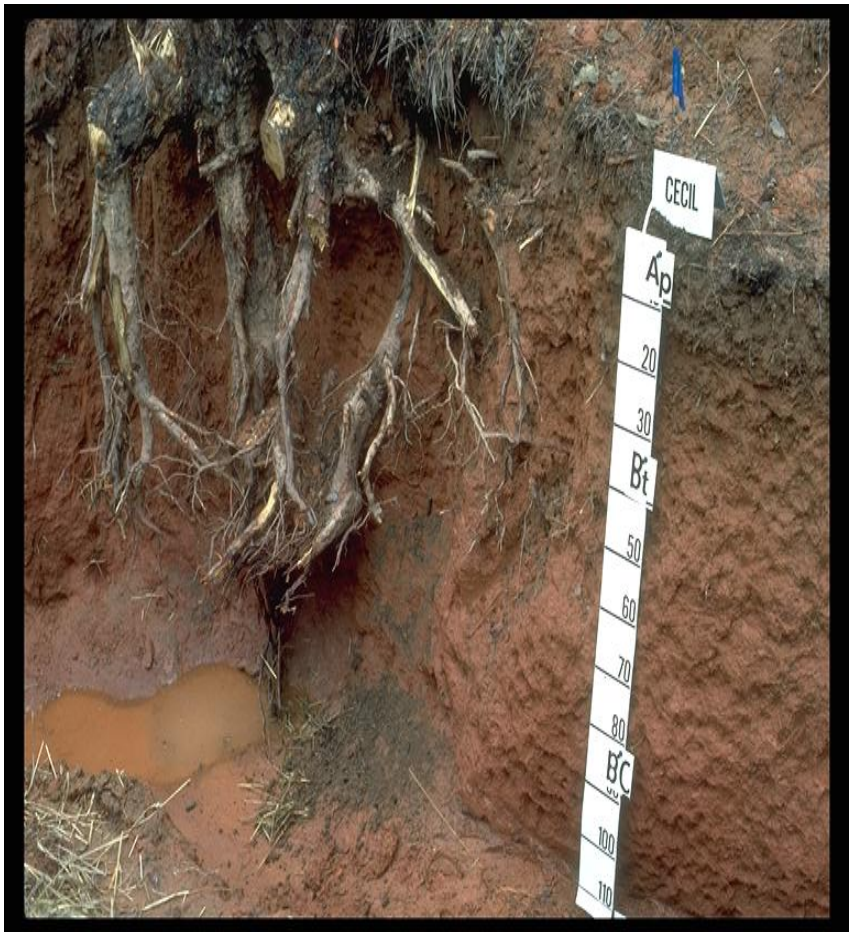
- **Natural process** - Intact Forest (0.05 to 0.10 tons/acre/year)
- **Accelerated process** - Agricultural Lands (3 to 15 tons/acre/year)

Fire Effects - Somewhere in between for most, but can be much more.

Erosion increases when. . .

- **Slopes are steep and long.**
  - **Forest floor is removed (soil is exposed).**
  - **Erodibility of the soil (K factor) is high.**
  - **Rainfall/runoff events are in intense**

If the forest floor (duff layer) remains intact, erosion is essentially nil.

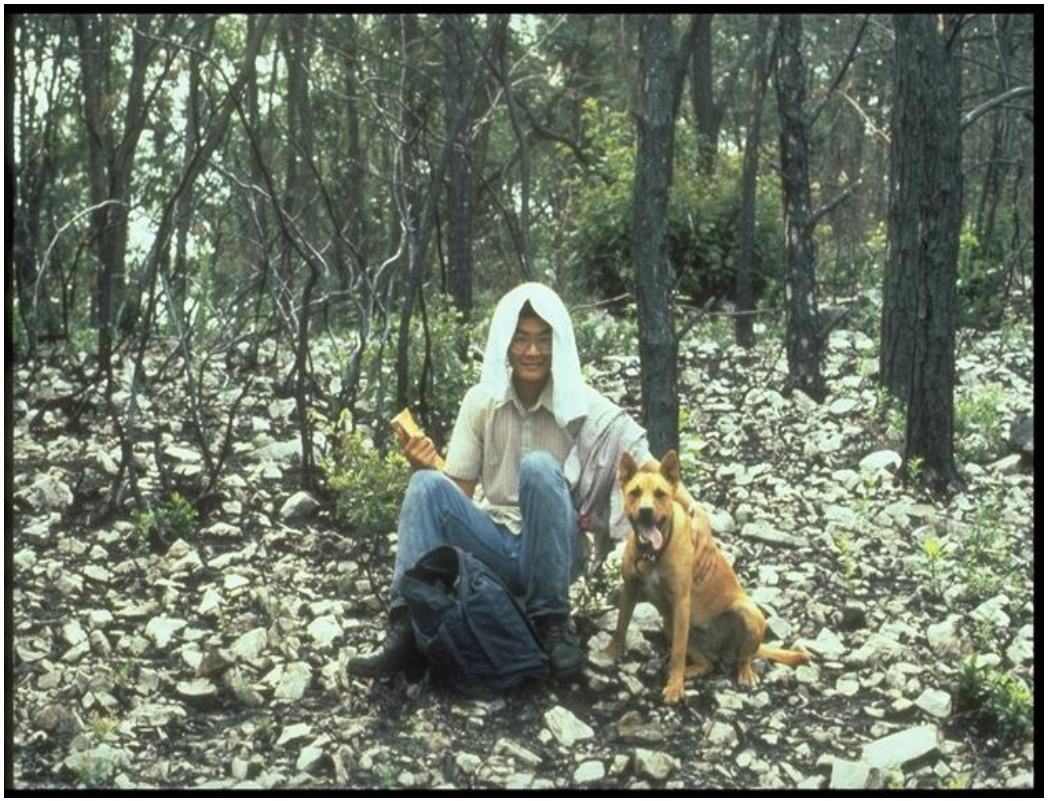


Erosion following

fires occurs when

forest floor is

consumed.



Universal Soil Loss Equation:

$$A = RxKxLSxCP$$

where:

***A* = soil loss (tons/acre/year)**
***R* = rainfall and runoff factor**
***K* = soil erodibility factor**
***LS* = slope length and steepness factor**
***CP* = cover + management practice factor**

Also: WEPP

LS Factor

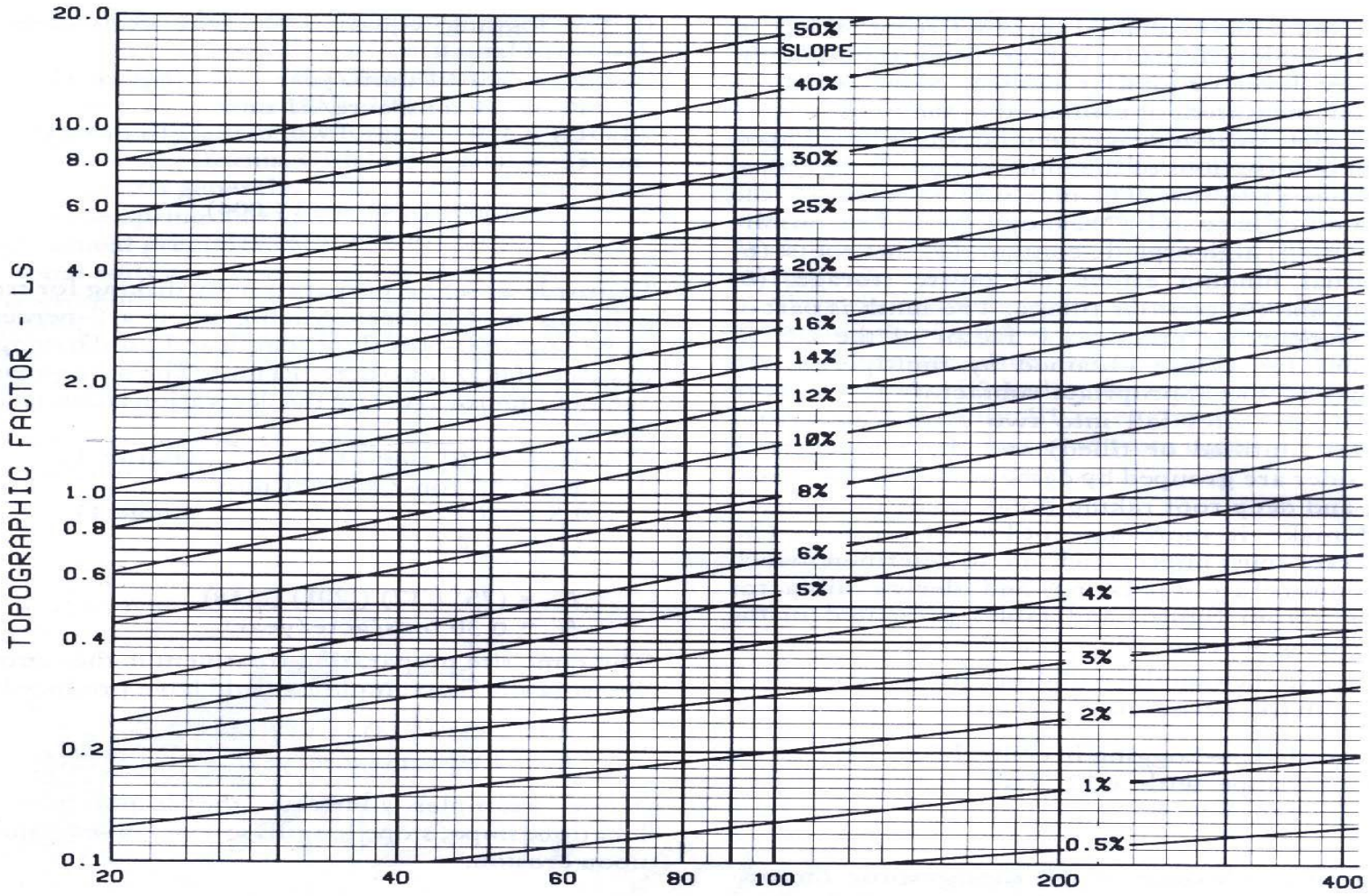


Figure 3.—Slope effect chart.[1]

[1]Topographic factor, LS. LS = $(\lambda/72.6)^m$ (65.41 $\sin^2\theta$ + 4.65 $\sin\theta$ + 0.065) where λ slope length in feet; θ = angle of slope in degrees and m = 0.2 for gradients less than 1 percent, 0.3 for 1 to 3 percent slopes, 0.4 for 3.5 to 4.5 percent slopes, and 0.5 for slopes of 5 percent or greater (7).

Rainfall Index in the U.S.

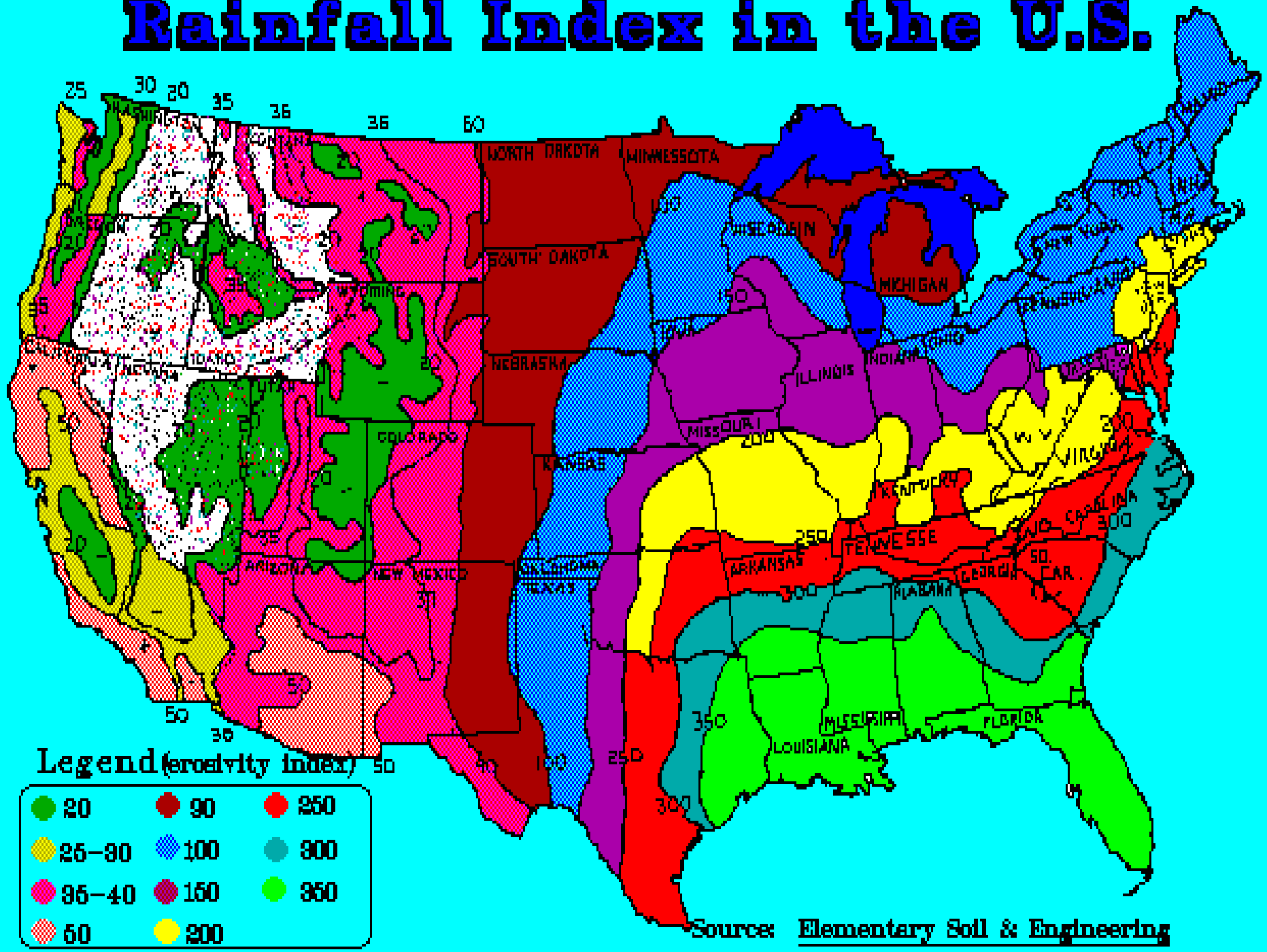


Table 2: K Factor Data

Texture	< 2 %OM	>2 %OM
Clay	0.24	0.21
Clay Loam	0.33	0.28
Fine Sand	0.09	0.06
Silt Loam	0.41	0.37
Silty Clay	0.27	0.26

Land Use “P” Factor
(Intact litter layer)

Row Crops	**0.24**
Pasture/hay	**0.05**
Urban, low density	**0.03**
Deciduous Forest	**0.009**
Evergreen/Coniferous Forest	**0.004**
Mixed Forest	**0.007**
Forest/Woody Wetland	**0.003**

USLE “C” Factor

	Percent Ground Cover					
	00	**20**	**40**	**60**	**80**	**95-100**
Grass	.45	.20	.10	.040	.013	.003
Forb	.45	.24	.15	.090	.043	.011

Fire can have a Major Effect on Nutrient Cycling

- **N, C are volatilized (LOSS)**

- **Metals, Cations**

(P, K, Ca, Mg) are released (GAINS)

Effects of Wildfire on Surface Soil in Table Mt./Pitch Pine Shenandoah National Park, VA

Fire Severity Level	pH	N kg/ha	C kg/ha
High	4.5	200	9,400
Low	4.4	288	13,200
Unburned	4.3	306	14,500

Effects of Wildfire on Surface Soil in Table Mt./Pitch Pine Shenandoah National Park, VA

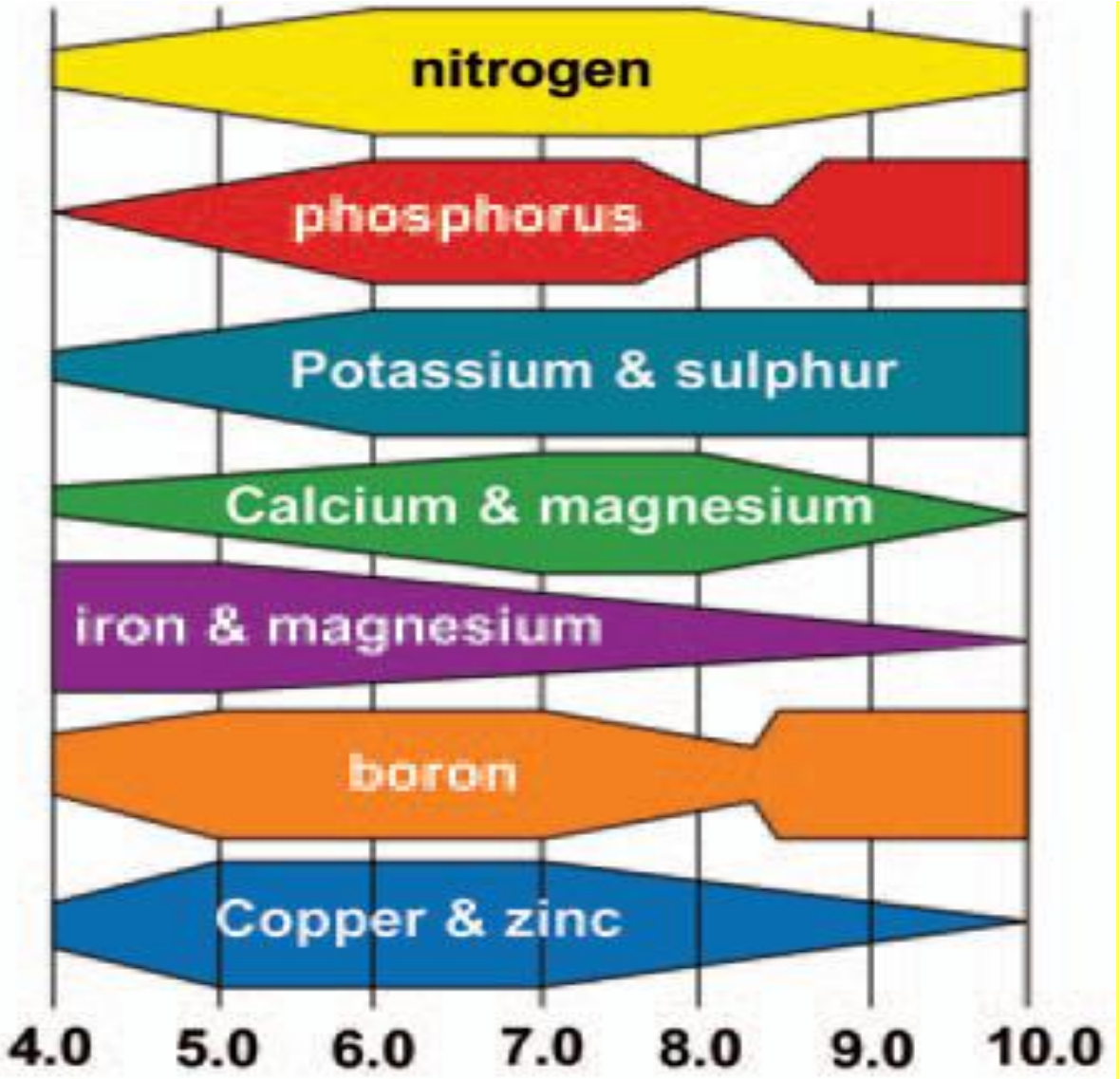
Fire Severity Level	P kg/ha	Ca kg/ha
High	2.0	29.0
Low	1.3	31.4
Unburned	0.3	11.3

Losses of N following fire are often

off-set by increased rates of N_2-fixation

by legumes.

pH
and
Nutrient
Availability



pH

Erosion following

fires occurs when

fire lines travel

upslope and

remain exposed.

Table 2.4— Soil surface conditions effects on infiltration, runoff and erosion.

Soil surface condition	Infiltration	Runoff	Erosion
Litter charred	High	Low	Low
Litter consumed	Medium	Medium	Medium
Bare soil	Low	High	High
Water repellent layers	Very low	Very high	Severe

SOIL DAMAGE:
"RULE OF THUMB"

- **Soil Surface: Black or Brown –**
  Negative Impacts Minimized
- **Soil Surface: White -**
  Carbon and Nitrogen Losses
  Excessive, Erosion Potential High
- **Soil Surface: Orange –**
  You Messed Up Bad!

Impacts on Water

- Sedimentation
- Eutrophication
- pH Increase
- Dissolved Oxygen Decrease

Air Quality Impacts

- Particulate Additions
- Addition of Gasses
- Visual Quality Impairment

Effects of Wildfire Vs. Prescribed Fire

- **Prescribed fire – Less intense, less variable**
- **Wildfire – Can be more/less intense, but generally more**
- **For example – Repeated, low-intensity, prescribed burns have had little, long-term, effect on soil N or C**